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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN NO. 21.
(Revised Edition.)

REPORT

OF A

TRIP TO AUSTRALIA

MADE UNDER DIRECTION OF THE ENTOMOLOGIST

TO INVESTIGATE THE

NATURAL ENEMIES OF THE FLUTED SCALE,

BY

ALBERT KOEBELE.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY,
Washington, D. C., November 22, 1889.

SIR: I have the honor to submit for publication Bulletin No. 21 of this Division, being the report of Mr. Albert Koebele upon the Fluted Scale (*Icerya purchasi* Maskell) and its natural enemies in Australia. I had intended to incorporate it in my forthcoming annual report, but the limited space alloted to that report makes it necessary to publish this as a separate bulletin.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The following report by Mr. Albert Koebele, one of the California agents of the Division of Entomology, gives an account of his trip to Australia, made during the late summer and fall of 1888 and the winter of 1888–'89, under instructions from this Department, for the purpose of investigating the Australian natural enemies of the Fluted Scale (*Icerya purchasi* Maskell) with a view to introducing the most efficient of them into California.

Failing to secure a specific appropriation from Congress for this purpose, although assisted in the attempt by the California delegation, and particularly by the Hon. C. M. Felton, and failing also to secure the removal of the clause restricting travel to the limits of the United States, we were led to accomplish the result through the kindness of the Department of State, in connection with the Melbourne Exposition, an arrangement having been made whereby two of the salaried agents of the Division should be temporarily attached to the Commission, their expenses, outside the United States, to be defrayed by the Commission, within the sum of $2,000. The warm thanks of this Department are due to the Department of State for this coöperation, and particularly to the Hon. Frank McCoppin, commissioner-general to the Exposition, to whom the matter was submitted by the State Department for approval. Mr. McCoppin at once accepted the proposition, and upon Mr. Koebele's arrival in Australia helped him in every way possible to make the experiment successful.

Mr. Koebele was sent, as just stated, for the specific purpose of studying and importing the natural enemies of the Fluted Scale, while the other agent, Mr. F. M. Webster, was sent to make a special report to the Commission on the agricultural features of the Exposition. Mr. Webster's report has been sent to the Commission, and was formally submitted to Mr. McCoppin. A copy of the present report, although purely entomological, and having little relation to the Exposition proper, has also been transmitted to Mr. McCoppin, as the results of the mission are, and ever will be, connected with his exposition work.

While a number of other entomological matters are referred to in the report, Mr. Koebele never lost sight of the main object of his mission. How successful it has proved late reports already published in INSECT

LIFE, and elsewhere, have abundantly testified. They have more than justified the anticipations expressed in my last annual report:

> We fully expect to learn of the increase and rapid spread of this new introduction as well as some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of southern California will be kept measurably freed of the pernicious Fluted Scale without so great an effort on the part of the growers or so great expense in destroying it. That nature will, with the new conditions induced by these importations, come to the relief of the fruit-grower, and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific Coast is our sincere belief which we hope to see verified. Not that we expect the Icerya to be ever entirely exterminated; but it will be kept under subjection so as to be comparatively harmless, as it is in its native country.

One of the insects imported, viz, the Cardinal Vedalia (*Vedalia cardinalis* Mulsant), has multiplied and increased to such an extent as to rid many of the orange groves from Icerya and to promise immunity in the near future for the entire State of California. In fact, the rapid multiplication and the effective work of this little beetle are almost incomprehensible until we come to consider its power of increase in a climate like that of southern California, where there is scarcely any cessation in its activities.

A careful account of the transformations of the Vedalia has been prepared by Mr. Coquillett and was published in INSECT LIFE for September, 1889, pages 70 to 74. I reproduce the figures in connection with Mr. Koebele's report in order to familiarize those who have not yet seen it with its appearance. I have also had some other figures made to accompany the report.

The period from the laying of the eggs until the adults again appear occupies less than thirty days for the Vedalia. At this rate of increase, calculating that three hundred eggs are laid by each female, and that one half of these produce females, it will readily be seen that in six months the offspring of a single female beetle may under favorable circumstances amount to over twenty-two trillions. So far it has not been noticed to prey upon any other insect than the Fluted Scale, a fact which accounts somewhat for its exceptionally rapid work and renders the outlook extremely encouraging.

Of the other enemies of the Icerya referred to and more particularly mentioned in the latter part of Mr. Koebele's report, none of them have so far given much promise, and there is risk of their not being colonized by virtue of the extraordinary spread and increase of the Vedalia, which has swept away from whole regions the Fluted Scale, upon which they depend. This contingency should have been avoided and I very much regret that they have not become established in California, because their establishment, and especially that of the little Dipteron, *Cryptochætum iceryæ*, would have helped in the general subjection of the pest and would be particularly valuable whenever the Vedalia, for whatever reason, at any time practically forsakes a given locality.

Where possible I have endeavored by foot-notes to add to the specific accuracy of the insects referred to.

C. V. R.

LETTER OF SUBMITTAL.

ALAMEDA, CAL., *July* 7, 1889.

SIR: I herewith submit my report upon the study of *Icerya purchasi* in Australia and New Zealand and the introduction of its parasites and enemies into California, undertaken under your direction and in accordance with your letter of instructions. *

Respectfully yours,

ALBERT KOEBELE,
Special Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

*The following is extracted from the letter of instructions:

WASHINGTON, *July* 3, 1888.

* * * As you are already aware you are sent to Australia for the purpose of making an investigation of the parasites and other natural enemies of *Icerya purchasi* with a view of introducing them into California. It will be necessary for you to go to Adelaide to see Mr. Frazer S. Crawford, who sent over the first Dipterous parasites and the *Cœlostomas* (or rather *Monophlœbus crawfordi*). This Dipterous parasite has been named by Dr. Willsiton *Lestophonus iceryæ*, and at Adelaide you will probably be able to study this insect carefully. Make the most careful investigations where you can learn of the occurrence of *Icerya* and find all of its natural enemies in Australia. Find out also the periods at which these parasites oviposit and ascertain the season at which success in importation will be most likely with each and all of them. Once on the ground you can see for yourself just what will be necessary to be done in order to bring about this result. You should also endeavor to place the Department in correspondence with as many observers as you can interest in the subject, and should by all means endeavor to get at least one man who will be able to devote some time to the matter and continue observations after you leave. It is barely possible that we may be able to re-imburse some such person for the time expended, but for this I will write you later, if indeed I do not see you personally in Australia in November. You will, of course, inquire immediately upon arriving in Melbourne concerning the largest orange-growing districts in Australia, and also make inquiries as to the best places for observing *Icerya*, aside from Adelaide. If you will visit the Botanic Gardens in Melbourne you will be able to get some information there. Baron von Mueller, formerly director of the Botanic Gardens, is still a resident of that city and you will find him a very well-informed person to consult. I inclose you letters of introduction both to Mr. Crawford and Baron von Mueller. * * *

On this trip your salary will be paid as usual by this Department, but your expenses by the Department of State through Mr. McCoppin. * * *

REPORT OF THE FLUTED SCALE OF THE ORANGE AND ITS NATURAL ENEMIES IN AUSTRALIA.

By Albert Koebele.

In accordance with the commission received from the Hon. Norman J. Colman, United States Commissioner of Agriculture, and your letter of July 3, 1888, I left San Francisco on August 25, and arrived at Auckland, New Zealand, on September 14, where some hours were spent in getting information in regard to Icerya. I visited Mr. W. Will, editor of the *New Zealand Herald* and *Auckland Weekly News*, who then, and subsequently on my later visit, gave me valuable information in regard to the occurrence and disappearance of Icerya in the Auckland districts, as well as many other points of interest in horticulture; and also Mr. T. F. Cheeseman, curator of the Auckland Museum, who readily accompanied me to a place full of *Albizzia* (*Acacia*) *lophantha*, Bentham, which had been about three years previously completely covered with Icerya. I made a careful search for specimens on these trees, yet only four full-grown females with large egg-sacs could be found. On one of the scales two rather large mites were feeding, attached to the under side; and the masses of old and moldy remains of Icerya were still visible on the trunks of trees.

A residence on which formerly were many orange trees was also visited. There all of the trees had been cut down on account of the numerous scales, and at the time of my visit no Icerya could be found and none were observed during the year as the proprietors informed me. No one was able to state the exact reason of the disappearance of the scales; some disease was the supposed cause.

The steamer left Auckland the following day and arrived in Sydney, New South Wales, September 20. I remained there for four days in search of Icerya. On my first walk a number of them were discovered at the town hall premises, infesting a Pittosporum (*P. undulatum*), and the succeeding days a few more were found in one of the public parks, also on this Pittosporum. A large isolated acacia tree full of the scales was found in front of a private house in the eastern part of Sydney; all were full-grown females with more or less developed egg-sacs and ap-

parently in a healthy condition. As the trees infested were all inclosed, no proper examination could be made and the few obtained at the town hall showed no trace of parasites. A trip was also made to Parramatta, about 14 miles to the west of Sydney, to look into some of the orange orchards. I found nearly all the trees badly infested with the red-scale (*Aspidiotus aurantii* Maskell, Fig. 1), and still worse with what I con-

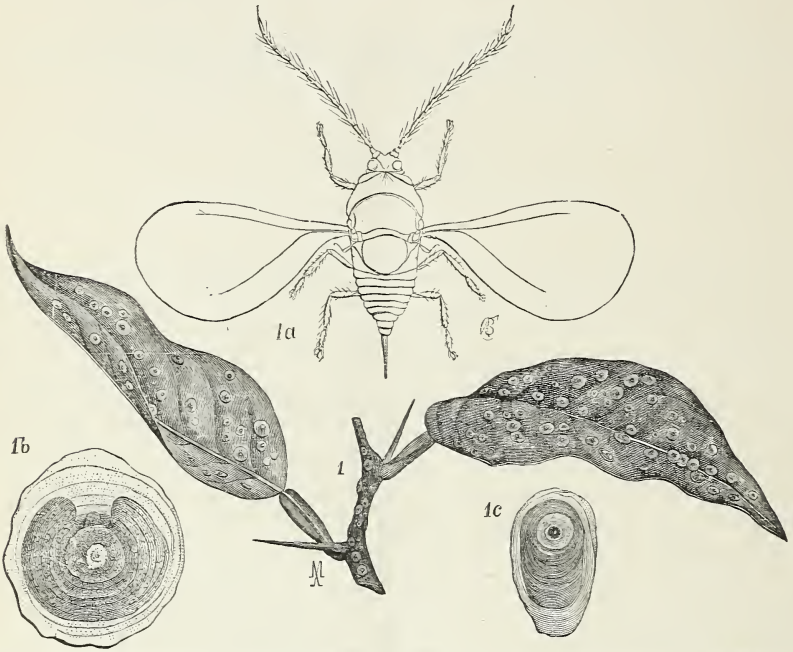


Fig. 1.—*Aspidiotus aurantii* Maskell: 1, scales on leaf of orange, natural size; 1*a*, adult male; 1*b*, scales of female; 1*c*, scale of male—enlarged (after Comstock).

sidered to be *Mytilaspis gloverii* Packard.* Indeed, some of the trees are completely covered by this latter scale, having the appearance of an old coat of whitewash on the bark which had partly fallen off. None of the several orange-growers there visited had ever seen an Icerya or was familiar with the insect. I left Sydney on the 24th and arrived in Melbourne the following day, having in the meantime, through the kindness of the United States consul, obtained a free pass over the New South Wales Railway, which courtesy was shown me by all the colonies subsequently visited. Indeed, I can not speak too highly of the kindness shown me by all the Government officials, and of the interest they took in the successful execution of my work. I remained in Melbourne for six days, during which time I visited Baron Ferdinand von Mueller, to whom you had given me letters of introduction. This gentleman assured me that the Icerya never became extensively injurious in Aus-

*A careful study of the pygidial characters of this scale shows it to be much nearer *M. pomorum* than *M. gloverii*. It seems, however, to be distinct from the former and will probably prove to be new.

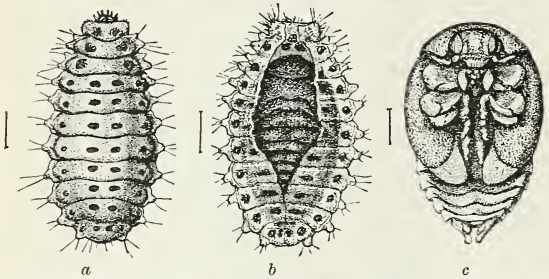
tralia. Occasionally and in certain spots they became numerous, but always disappeared again. I also met Mr. C. French, Baron von Mueller's assistant, who has had some experience in entomology. He claims that the scale has been known to him for thirty-four years, yet he has never seen it in large numbers.

At the Zoological Gardens I found on a species of Eucalyptus a coccid in such numbers as to cover the under side of all the larger branches and the stem in part. Many of the winged males were secreted among the crevices of bark, with their two long white setous hairs protruding. Numerous larvæ of a coleopter were found under chips of bark feeding upon the scales, apparently belonging to some clerid. I never met with these larvæ again in my later researches nor with the coccid mentioned. A great variety of scales was observed at Melbourne; the most pernicious amongst them, a species of *Aspidiotus*, deserved attention. This is *A. rossi* Crawford, figured on his plate 18 of the Coccidæ, but as yet no description has appeared to my knowledge. I have seen olive trees completely covered by this scale; it will attack almost any kind of tree or shrub as I later observed. Many of the shrubs in the Botanical Gardens in Melbourne infested by this scale were in a dying condition. The introduction of this pest would be of serious consequence to the United States and we should be on our guard against this as well as a second species of waxy scale, probably a species of *Ceroplastes*. This last is covered by a thick, smooth, white, waxy matter which effectually protects it. Nothing would destroy this scale, except remedies against the newly hatched larvæ, which, before they exude any wax, are easily killed. The insect was observed all over eastern Australia, and it was numerous in the Botanical Garden at Sydney and in the woods near Brisbane. At the Botanical Gardens they could find no remedy except cutting down the infested plants. I recommended a strong resin wash for the newly hatched larvæ. No Icerya could be found during my short stay at Melbourne.

I arrived at Adelaide, South Australia, on October 2, with letters of introduction to Mr. Frazer S. Crawford, of the surveyor general's office, who received me very kindly and promised me his assistance, which promise he honorably fulfilled throughout my stay in Adelaide. I saw the man who discovered the parasites of Icerya (*Lestophonus iceryæ*), and, indeed, felt very happy when he promised to show me a large colony of the scales on the following day. Early the next morning Mr. A. Molineux, agricultural editor of the *South Australian Register and Adelaide Observer*, and proprietor of the *Garden and Field*, showed me about a dozen orange and lemon trees in a private garden in the suburbs of Adelaide all more or less infested with Icerya, and had been so for the previous two years. The scales were nearly all full grown, or rather nearly all of them had begun to exude cottony matter and deposit eggs, yet they were not quite so far advanced as those observed at Sydney.

The very first scale examined contained nine pupæ of the parasitic fly, *Lestophonus*, and the scale was still living. Nearly all of the many

others examined proved to have either larvæ or puparia within them; none of the flies had at that time made their appearance. I attended the gardeners' meeting at Adelaide on October 6, in order to get information as to the occurrence of Icerya, yet but very few of the gentlemen were acquainted with the insect. To show how rare Icerya is in South Australia, Mr. J. G. O. Tepper, of the museum at Adelaide, a qualified entomologist, who has collected insects all his life, has known Icerya only for the last two years. He never met before this with any specimens in all his collecting trips through South Australia. On October 15 I made a trip with Messrs. Crawford and Tepper to North Adelaide, where some Icerya were said to exist; we found there in one garden a few orange and lemon trees with the scales, which were subsequently collected for shipment. In another garden, and also on orange, an occasional specimen was found. I discovered there, for the first time, feeding upon a large female Icerya, the Lady-bird, which will become famed in the United States—*Vedalia cardinalis* (Figs. 2 and 3). I called the attention of both the gentlemen to this insect, yet neither of them had ever seen it nor knew the beetle. Mr. Tepper has charge of a large collection of insects, and especially of Coleoptera, at the South Australian Museum. Mr. Smith, the proprietor of the nursery, also called my attention to a beetle, a curculio, which is very destructive to olive-trees, eating the young shoots and leaves of the plants during the night and secreting itself in the ground during the day-time (Fig. 4).*



a b c

FIG. 2.—*Vedalia cardinalis: a*, full-grown larva; *b*, pupa, dorsal view, inclosed in last larval skin; *c*, pupa, naked, ventral view—all enlarged (after Riley).

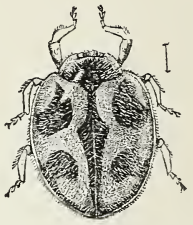


FIG. 3.—*Vedalia cardinalis*, adult—enlarged (after Riley).

FIG. 4. — Olive Snout-beetle (*Otiorhynchus cribricollis*)—enlarged (original).

Through the bureau of forestry at Adelaide I was informed that a colony of Icerya existed at Mannum, on the Murray River, and a trip to that place was made on October 18. In two gardens Icerya was present; in one of them they existed on only a few of the many orange-trees, and none examined showed any parasites, while in the other on two

* Dr. Sharp, to whom we submitted specimens, has kindly determined this beetle to be *Otiorhynchus cribricollis* Gyll., a common pest to the Olive in the Mediterranean region.

trees that were infested many of the scales were parasitized. In addition to the parasites, numerous larvæ and eggs of a lace-winged fly (*Chrysopa*) were observed, the larvæ preying upon the scales and chiefly upon their eggs. They were covered so much with the cottony matter of Icerya as to resemble this insect very closely, and were difficult to pick out from the torn masses of egg-sacs. I also observed here a coleopterous (*Coccinellid*) larva, seen before at Adelaide, feeding on the scales, and this proved to be that of the Vedalia. All the scales here, as well as all the predaceous larvæ found feeding upon them, were collected and taken to Adelaide to be shipped to California, together with those found at the latter place. They were kept boxed in a cool cellar. The scales in Adelaide and suburbs were collected on October 24 and 25 at a place in North Adelaide. Nearly every one of the Iceryas exposed to light and sun contained parasites, and many of these had already left, as numerous holes were visible. Of the scales found on a small and bushy mandarin tree, where they were excluded from the sun, only a few contained parasites, but the larvæ of the *Chrysopa* were abundant. Most of the larger egg-sacs of Icerya were torn by them and the contents devoured.

I observed also that many of the young scales, only sufficiently large to contain a single puparium of the fly, were infested, the expanded skin of Icerya forming a thin covering over the puparium of the *Lestophonus*. This was observed at all places where Icerya occurred. No doubt the eggs of the pest must be deposited while the scales are yet quite small, probably even before the first molt, and certainly later, as the scales will go on feeding and increasing in size until the larvæ within them pupate. At this time large numbers of the scales were hatching and also of the flies. Only one living fly was observed on October 24 while collecting the scales, sitting between two large egg-masses and hardly visible to the eye. This and a second specimen taken under similar circumstances were the only ones I observed in nature. I have never met with a single specimen depositing eggs or even sitting on an Icerya nor flying around. I finished collecting for my first shipment on the 25th and estimated that I had about 6,000 Icerya, which in return would produce at an average about four parasites (*Lestophonus*) each. They were packed partly in wooden and partly in tin boxes. Small branches generally full of scales were cut so as to fit exactly lengthwise into the box. With these the boxes were filled and all loose scales placed in between, plenty of space remaining for any of the insects within to move about freely without danger of being crushed by loose sticks. Salicylic acid was used in small quantities in the tin boxes to prevent mold, yet these, as I have been informed by Mr. Coquillett, arrived in a more or less moldy condition, while those in wooden boxes always arrived safe. In addition, Dr. Schomburgh, director of the botanical gardens at Adelaide, kindly fitted up for me a Wardian case which was filled with living plants of oranges and *Pit-*

tosporum in pots. Large numbers of Icerya were placed in this, and such larvæ as were found feeding upon them, including some of a *Scymnus** (Fig. 5), only occasionally found with Icerya, yet very abundant on various Eucalyptus scales, especially on *Eriococcus eucalypti*. Of this I sent large numbers to California in my later shipments, as they were easily collected by the hundreds under bark of Eucalyptus infested with this *Eriococcus*. Mr. F. M. Webster brought me the same insect in numbers from Tasmania, together with the *Eriococcus* on Eucalyptus. The object of this was to have the *Lestophonus* go on breeding within the case during the voyage. No doubt many infested scales arrived in Los Angeles.

FIG. 5.—*Rhizobius ventralis* Er.—enlarged (original).

I found on examining the tree, on April 12, 1889, under which this case had been placed with a tent over it, that from several of the Iceryas the *Lestophonus* had issued. This case, as Mr. Coquillett informed me in letter of November 30, arrived in good condition, except that the putty had been knocked off in several places, leaving holes large enough for the parasites to escape. Before opening the case he found two coccinellid larvæ crawling on the outside, and these when placed with the Icerya attacked it at once. He further said that there were only about half a dozen living *Chrysopa* adults. This would show that the *Lestophonus* was still issuing on arrival in California and all turned out more favorably than I had anticipated on seeing the box handled in such a rough manner by the steamer hands at Sydney, to which point I accompanied this as well as all the subsequent shipments. I expected little good would come out of this method of sending and therefore concluded to send only small parcels on ice thereafter, as had been partly done at first. If once the insects could be placed in good condition in the ice-house on the steamer just before leaving, where a temperature of 38° Fah. at first and about 46° Fah. on arrival in San Francisco existed, they must arrive safely. To accomplish this, the parasites with their hosts were all collected the last three days before leaving Adelaide, and on arriving home were immediately placed in a cool cellar. On the trip from Adelaide to Sydney, which takes two days by train, my insects came generally in an ice-box on the sleeping-car.

On November 2 I made a trip to Gordon, 11 miles north of Sydney, Mr. James Harold, agricultural reporter of the *Town and Country Journal*, Sydney, having furnished me with the address of a prominent fruit-grower there. Mr. Harold has traveled much over Australia gathering information for his paper, yet, as he assured me, he never met with an Icerya. The same answer was received from the gentleman at Gordon, who has been living in the colony for thirty-four years and has raised oranges for thirty-two years. He knew only the three scales upon

* Dr. Sharp described this as *Scymnus restitutor* (Insect Life, I, 364), but has since written us that it is identical with *Rhizobius ventralis* Er., of the Munich catalogue. He states, however, that it belongs rather to *Scymnus* than to *Rhizobius*.

oranges, viz: *Lecanium oleæ* (Fig. 6) and the *Mytilaspis* and *Aspidiotus aurantii.* This latter is not doing any serious damage to his trees, providing they are well taken care of, yet he assured me that in some parts of the colony it is impossible to raise oranges on account of the ravages of this scale. For the *Mytilaspis* he uses sulphur and lime as a wash, applying it with a paint brush. This he claims need only be repeated every three years, as during this time the trees remain comparatively free. The mixture is prepared in the following way:

Unslacked lime, two parts; sulphur, one part; water is poured on this in sufficient quantities to boil and unite with it. It is applied as a white-wash to the trees and to prevent injury should not be too strong

FIG. 6.—*Lecanium oleæ:* 1, adult females on olive leaves—natural size; 1*a*, female—enlarged (after Comstock).

Besides the scales, an Aphis appears occasionally on orange and peach trees. Two beetles are numerous and destructive to the melon vines here. One of them found at the time is a *Diabrotica*, often received by Mr. Crawford, of Adelaide, as doing great injury to the melon tribe. This gentleman, however, claims that all injury can be avoided by dusting powdered lime over the plants. The beetles, he said, will not attack leaves thus treated. I found here, as well as all over Australia and New Zealand, the Woolly-Aphis (*Schizoneura lanigera*), yet they could be seen only on the branches, as all or nearly all the apples raised in the colonies and New Zealand are said to be grafted on blight-proof

stock. For this purpose, the Northern Spy of our continent is considered the best; next comes the Majetin, as Mr. Will, of Auckland, informed me. The Irish peach was standing completely free of Aphis between badly infested trees. A large number of blight-proof trees are sold by nurserymen in Australia and New Zealand, and only such are planted in these countries as far as the roots are concerned. Mr. Will said that the Northern Spy will produce the best roots; on this is grafted the Majetin as the stem, and any desired variety may be selected for the upper part or branches. At this place I observed a small black and lemon-yellow lady-bird (Fig. 7) feeding upon the Woolly-Aphis; the same was also observed at Toowoomba, Queensland, under similar circumstances.* I did not meet with it outside of these places. No Icerya could be found on the orange trees, but the same day, two young specimens were found in the woods, about 2 miles distant, one of them on a pea-vine and the second on a species of *Salix*, both near the ground.

FIG. 7.—*Leis conformis*, found feeding on Woolly Aphis—enlarged (original).

November 5 I visited Mr. Joseph Purser at Castle Hill, to the west of Sydney, also a prominent fruit-grower. No Icerya were found on the numerous orange trees at this place. Mr. Purser reports having met with an occasional specimen only on his orange trees, never more than half a dozen. A short distance from the orchard I noticed a small pond on the edge of which were growing a few small bushes of Acacia. On examination I found two large Iceryas with egg sacs and several empty skins of scales. Mr. Purser informed me that in former years he has often seen the scales upon trees growing along river banks. During this same day, while searching through the bush, I found upon the needle-bush *Hakia acicularis*, growing amongst numerous *Acacia longifolia*, a well developed Icerya fastened to the main stem. A careful search was made on all the plants growing there, yet with the exception of a peculiar Cœlostoma upon Acacia, no scales could be found. One specimen of Icerya was found on this Acacia at the botanical gardens in Adelaide. Mr. Purser, who is also much troubled with the *Mytilaspis* mentioned, used as a remedy kerosene-tar, 1 pint; soft-soap, 3 pounds; sulphur, 5 pounds. These are boiled in 10 gallons of water and the trees washed with this mixture with a paint-brush, only the trunk and larger limbs being treated. The gentleman claims that all the scales on trees so treated will be killed and the trees will remain free from scales from seven to nine years.

I returned to Adelaide on November 8, as I considered that the best field to obtain the material. On the 15th a trip was made about 300 miles north of Adelaide, but I found nothing of interest in the insect line on this journey, with the exception along the road of large num-

*This species is *Leis conformis* Boisd., according to Dr. Sharp, to whom we sent specimens.

bers of locusts traveling south in search of food, nothing being left for them in the interior to feed upon. The country around Quorn was so dry and hot that some *Eucalyptus rostrata* in a dry river-bed were all the green vegetation that could be seen, and the locusts still met with were unable to feed. Finding the search for Icerya in this district useless, I returned to Adelaide, where subsequently new colonies were discovered for shipment. In conversation about the grasshoppers en route, a gentleman remarked that only in such unusually dry seasons as the present would the locusts migrate, there being no food left for them in the interior of South Australia. Those around Quorn, he remarked, left in a southeasterly direction down the valley toward Adelaide, while those coming from the interior went towards Spencer's Gulf. On my trip I observed them most abundantly about Black Rock traveling south, not in clouds but scattered and never very high, similar to our *Caloptenus devastator* in California in 1885.*

November 29 I began collecting material for my second shipment. Already on some of the trees, well exposed to sun, about 90 per cent. of the flies had left the scales, while on the trees in more shady places more than half of the parasites were still within their hosts. Not a single fly was observed, and yet they must have been about in large numbers. Instead of this, I noticed sitting and walking about the scales a peculiar Chalcid† (Fig. 8); this was suspected to be a secondary

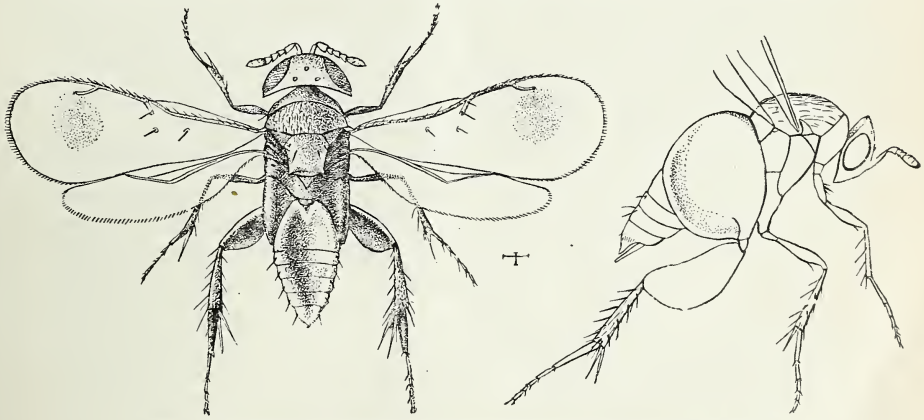


FIG. 8.—*Euryischia lestophoni*, dorsal and side views—enlarged (after Riley.)

parasite, and during the day I noticed them ovipositing in the infested Iceryas. The Lady-birds were at that time quite abundant in egg, larva, pupa, and imago states, and special pains were taken not to miss any of these during the collecting. The following four days were

* As kindly determined by M. Henri de Saussure, of Geneva, Switzerland. This is the *Chortologa australis* of his monograph of the Tryxalidæ, not yet completed.

† This is the species referred to in our annual report for 1888, p. 92, under the MS. name *Euryischia lestophoni*.

spent in gathering Icerya and its enemies. Many of the secondary parasites were again noticed, yet not a single *Lestophonus*. I gathered during this time probably six thousand scales, and hardly a specimen was noticed among them that was not parasitized by the *Lestophonus*. All of them contained either puparia of the fly or empty holes where the flies had issued. Knowing that if we should introduce the secondary parasite the good work of *Lestophonus* on Icerya would be greatly restricted, I sent the following notice to Mr. Coquillett, and also to your office.

On account of a parasite of *Lestophonus iceryæ*, remove the infested scales that I send from the tree they were placed on, after six weeks, and transfer into large glass jars; examine daily by stupefying the insects that have issued, with chloroform or ether, empty contents on table, pick out the flies and destroy their parasites. Form a new colony with every consignment you receive.

In your letter of January 3 in regard to this secondary parasite you wrote:

The parasite bred from *Kermes* and the one from confined *Icerya* and which you think to be parasitic upon *Lestophonus* are different species of the same genus. The genus is an entirely new one belonging to the Chalcid subfamily *Elasminæ*. This subfamily is an extremely interesting one, and up to the present time has contained only the typical genus *Elasmus*, so that this finding of a new genus is important. *Elasmus* contains both secondary and primary parasites, so that it will be necessary to secure pretty good evidence regarding this new form before we can accept it as either one or the other.

From seventy-five specimens of *Kermes* no *Lestophonus* was bred. On the 26th I left Adelaide on my way to Sydney, with what I considered even a better shipment than the first. Unfortunately this lot arrived in a bad condition at San Francisco, owing to a gale on the route when the parcels fell off the shelving in the ice-house, in which they had been placed, and most of them were crushed by cakes of ice falling on them. In my opinion, even such severe treatment as this would not destroy so very many of the pupæ of *Lestophonus*, which are not soft, and if crushed out of the scale will produce flies if properly taken care of later, as I had ample opportunity to observe while in Australia.

Among this lot of things were also about fifteen hundred eggs of the *Chrysopa* which were collected on Kangaroo Acacia (*A. armata*) infested by a *Dactylopius*, which is often taken to be Icerya. The scale is sometimes so abundant that the plants are entirely covered with it. This was the case during my visit, and, as Mr. Crawford informed me, also in 1882. Mr. Maskell, to whom specimens were forwarded by Mr. Crawford, said that the insect belongs to the *Dactylopinæ*. The eggs of the *Chrysopa* were so abundant that often from twenty to thirty could be counted on a single small outer branch of a few inches in length, yet many of these had already hatched. The number of Lady-birds in all stages sent with this lot amounted to several hundred. The weather was unusually hot during two days of collecting, the thermometer registered 108° Fah. in the shade, and from one small box left in room over night, where the temperature had not been below 90° Fah., about

fifty of the flies issued during the night and early morning. They were crawling on the window at 6 a. m. Many more were found within the box, with wings not yet developed.

I returned again to Adelaide within four days, the time taken in making the trip. I wrote to the United States consular agent, Mr. George Harris, at Brisbane, Queensland, to ascertain for me the occurrence of Icerya in that district. Through the department of forestry at Adelaide I was informed that Icerya existed at Stansbury, on the Yorka Peninsula, at the place of Mr. F. Wurm. Accordingly a trip was made across the water on October 1, and I was kindly and hospitably received by Mr. Wurm. That gentleman showed me a small orange-tree completely covered with Icerya, but aside from this, not a single specimen could be found for miles around, nor had they ever been observed before this. The tree infested with the scales was completely covered with a small black ant, so much so that several could be counted upon each of the scales at the same time. Upon examination only two specimens of the Icerya were found to be parasitized by the *Lestophonus*, and these had already left. No doubt the abundance of the ants upon the scales prevented the flies from ovipositing. I recommended keeping the ants off the tree as the scales would then disappear.

How often must the mother flies have been hovering over this young tree in their attempt to lay eggs, and how many of them must have been carried off as food for the young of the industrious ants! Mr. Wurm also informed me that Icerya had been found by him upon the roots of black grass. On examination, however, this proved to be an entirely different coccid, *Lecanium oleæ*, which had found its way to this place in small colonies on olive-trees. The cut-worms had done considerable damage to fruit-trees, grape-vines, and other vegetation during November. Some of the apple-trees were completely stripped of their foliage. Melolonthid larvæ had been very injurious to the wheat crop by eating the roots.* The common grasshopper was also in abundance here.†

On December 6, from four large specimens of Icerya that had been inclosed, thirty-four flies (*Lestophonus*) and five parasites of the latter had issued. I examined condition of Icerya on place from which last sending was made, and from which nearly every one of the old and infested scales had been removed, the trees at the time being full of large Iceryas; yet at this date but very few of them were left, the coccinellid larvæ and the Chrysopa in conjunction doing good work, eating, no doubt, the healthy as well as the infested scales. Some of them had apparently gone through second molt, yet the greater part were

* Three species of Melolonthid beetles were collected at this point by Mr. Koebele, and being unknown to our fauna were sent to Dr. Sharp, who has found them to be *Scitala nigrolineata* Boisd., *S. pruinosa* Dalm., the third species representing a new genus near *Scitala*.

† The same undetermined species referred to on p. 17.

still in the first stage. Only very small larvæ of the *Lestophonus* were found within scales after first and second molts. Within a nearly full-grown specimen on trunk of lemon-tree, the only large one found there, two larvæ of the fly were nearly full-grown.

I left on December 10 for Melbourne, seeing that it was necessary to hunt up a new field. There I had hopes of gathering a sufficient quantity for a shipment. The largest colony I was able to discover at Melbourne existed in a church-yard on Collins street, upon small trees of *Pittosporum undulatum.* I could not find the proper person to apply to for admittance, and a policeman whom I consulted in regard to getting the tempting specimens advised me "not to jump from the fence as they surely would have me arrested."

I left them undisturbed and went in search of others. A few specimens existed in the gardens of the government buildings; an occasional specimen in the park adjoining the Exposition grounds; some on a hedge in front of a hotel, and single specimens were found on trees in a park at St. Kilda, while at the same place on a garden hedge quite a number were found; all these on *Pittosporum undulatum* and *P. (engenioides?)*. At the last-named place the lady-birds were found at work, and all were gathered later for shipment. I went east of Melbourne as far as Bairnsdale, yet no Icerya could be found. A strong attempt was made to find out the whereabouts of the Monophlœbids of which Mr. Crawford had sent specimens to California. They could not be discovered in numbers in the woods, yet in the parks at St. Kilda I was soon rewarded by finding the insects looked for, viz.: *Monophlœbus crawfordi* Maskell (Fig. 9), under loose bark of various Eucalypti, embedded in cottony matter, and the single, (often 2 inches) long, white, setous, anal hairs sticking out.* Only a few dozen of the monstrous scales, however, could be gathered in a hard day's work. Up in the tree-tops I often found a similar Monophlœbid, only varying in color somewhat. It is as large, or even larger, than *M. crawfordi*, and sits fastened to the branches and exposed without any cottony attachments, although sometimes under chips of bark.

On my way home in the evening one of these scales came hurriedly running down on the trunk of a tree. So the next day, at the northern park at Melbourne, the ground at the base of the Eucalypti was examined. Here I found, sometimes lying loose on top and dead (in this case always destroyed by *Lestophonus*) and below ground to a depth of 3 inches, in a small cave nicely embedded in loose cottony matter if healthy, or generally mixed up with the ground if parasitized, large numbers of these scales. These, Mr. Coquillett informed me on my return to Los Angeles in April, gave the best results in *Lestophonus*, as these parasites were still issuing then, four months after they were col-

*Not mentioned in the description of *Monophlœbus crawfordi.* See "On some New South Australian Coccidæ," by W. M. Maskell. (From the Transactions of the Royal Society of South Australia 1888.)—A. K.

lected. I have counted as many as sixty-two holes in one of these scales, showing what a number of parasites they are able to support. A third species of these large Coccids was found attached to the roots and base of Eucalyptus below ground, even larger than the two preceding. About forty specimens of these produced no parasites. One specimen, probably of this latter species, was found embedded under bark between the forks of a very large Eucalyptus about 8 feet from the ground. This measured fully 1 inch in length, and was about two-thirds as broad, being nearly round.

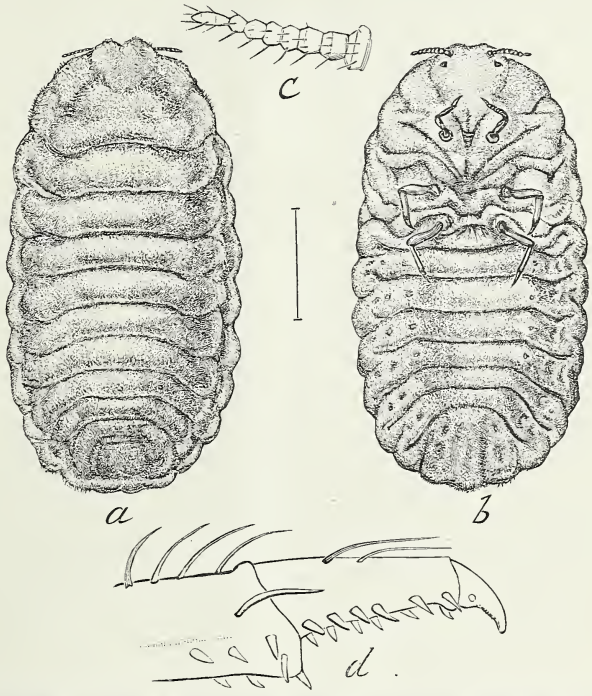


FIG. 9.—*Monophlœbus crawfordi: a*, female from above; *b*, same from below—enlarged; *c*, antenna; *d*, tarsus of same—still more enlarged (original).

I left for Sydney on the 24th to place the insects in an ice-house previous to shipment. In the meantime a letter had been received from Brisbane stating that Icerya occurred there occasionally in numbers, and having had a letter from you in which you expressed the hope that I would be able to visit Mr. Carl H. Hartmann, a correspondent of yours at Toowoomba, who had found Icerya on his oranges in 1886, I started for Queensland on December 29 and arrived at Toowoomba early on January 1, 1889. During the same day a full-grown female Icerya was discovered in the woods about three miles from this place on *Acacia decurrens*. During a search of several hours no other specimens were found. I visited the Range nursery the following day and met the son and the brother of Mr. Hartmann, who himself had died from the effects

of fever contracted while on a scientific trip to New Guinea. I also met the man who had been employed at the time in 1886 when Mr. Hartmann received an illustration from Brisbane of Icerya, and directed him to look over the trees for specimens, when several scales were found. Since then, however, none have been found. While looking over the lemon and orange trees I found one single nearly full-grown specimen, but aside from this no trace of them. A peculiar Coccid resembling Icerya somewhat in structure was found on an apple-tree. The gentleman informed me that Icerya was always most noticeable in wet seasons, but that it never appeared in such numbers as to be injurious.

I found here in abundance the large hemipterous insect so destructive to the orange in Queensland and New South Wales. A second species somewhat smaller than this, yet equally mischievous, was found at Adelaide (Fig. 10). Trees were observed at this place with all the fruit and most of the young shoots destroyed. Both species live and grow upon the sap of fruit and tender twigs.* *Aspidiotus aurantii* was present here in numbers and also *Lecanium oleæ*, both upon oranges; the latter, however, is kept well in check by a lepidopterous (*Noctuid*) larva, *Thalpochares cocciphaga*, Meyrick (Fig. 11).

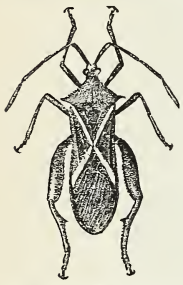


FIG. 10.—*Mictis profana*—natural size (original).

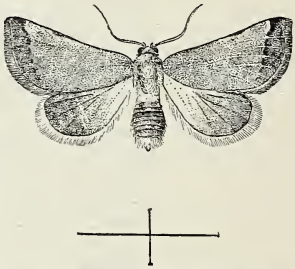


FIG. 11.—*Thalpochares cocciphaga*—slightly enlarged (original).

Several young orange trees had been completely cleaned by larvæ, and eight chrysalids were found upon a young plant. Mr. H. Hartmann also informed me that near Brisbane a dipterous larva existed which occasionally destroyed all the orange crops, and in 1886, which was a very wet season, a dipterous larva destroyed not only all the oranges but also nearly all the other fruits, even the apples and pears. He also gave me the following list as blight-proof apple-trees: "Northern Spy, Majetin, Irish Peach, Streaked Peach, Hartmann's Seedlings Nos. 1 and 5, New England Pigeon, Shepherd's Perfection, Chubb's Seedling, Canvade, Flushed Peach."

On January 5, having obtained free passes for the Queensland railways, I left Toowoomba for Brisbane. On my arrival at the hotel I met with specimens of Icerya on an ornamental plant in the passage-way. This and a few other specimens found in gardens through the city were all I could find, yet in damp seasons they occur sometimes in numbers, as I learned from several gentlemen acquainted with the insect.

Mr. Henry Tryon, assistant curator of the Museum, kindly introduced me to several persons in Brisbane. He himself was about to publish a

* The second of these insects is *Mictis profana* Fabr., and the other is a species of *Aspongopus*.

paper on Icerya and its parasites, of which he has shown me a small Chalcid of which he bred several specimens from Icerya inclosed in paper box, saying it was a true parasite.* I bred this same insect from a few specimens of an Icerya sent to me by Dr. Bancroft, of Brisbane, as feeding upon mangrove tree (*Avicennia officinalis*, Linn.). This scale differs in coloration from the true *I. purchasi* and may prove to be a new species. Mr. Maskell, to whom the insect was shown, thinks it only a variety. It would be an interesting one, however, for of all the *I. purchasi* that I have seen, none show such a uniform bright yellow color. No specimens found on mangrove at Auckland show such bright yellow color. Mr. Tryon is of the opinion that Icerya originated in China, from the fact that nearly all specimens he found at Brisbane were upon plants from that country. Dr. Bancroft, in his paper on Coccidæ (Philosophical Society of Queensland, vol. 1, August, 1869), referred to the then undescribed Icerya, and at that time, as he assured me, he had been acquainted with the insect for several years. The doctor further mentioned the occurrence of a scale on the sugar-cane in Queensland living on the roots of the young plants, and as these became larger, behind the leaves. It had been imported with the canes from Mauritius. He promised to secure specimens for me. No doubt this will prove to be *I. sacchari*.†

In the woods around Brisbane but few Coccids were found during my brief stay. The white waxy scale (*Ceroplastes*) so abundant on various plants in cultivation was here observed in large numbers upon a small shrub. Of the *Monophlœbus*, which I had been informed was almost always numerous around Brisbane, only an occasional specimen could be found. Everything was so extremely dry that I gave up my intended trip by steamer further north, and as there was little prospect of obtaining sufficient material for a shipment at this place, I returned slowly towards Melbourne, making occasional stops along the road, yet without discovering any Icerya. At Melbourne I was fortunate in finding many more of the *Monophlœbus*. On a few trees, under the bark, they occurred by the dozens, often many together, but they were all dried up and the flies had left sometime previous. Those in ground were still in good condition. A large number of them had deposited their eggs and were shriveled up, yet during the two days a fair number were found parasitized. At Sydney, January 21 to 23, a number of Iceryas with parasites, and probably two hundred or more of the Lady-birds in all

* Mr. Tryon has recently published in a pamphlet entitled "Report on Insect and Fungus Pests, No. 1," a general description of this parasite, but without attempt to name or properly place it. From the description it seems to be identical with a true parasite of Icerya, which we have received from Mr. Crawford, and which we have characterized, since the above was in type, as *Ophelosia crawfordi*, n. g., n. sp.

† We find among Mr. Koebele's Brisbane material a small Coccinellid not here referred to, but which is labeled "feeding on Icerya." Dr. Sharp, to whom we sent a specimen, determines it as *Cryptolœmus montrouzieri* Muls.

stages, were collected, most of them in the Town Hall garden. I found here also feeding upon the Scales a few specimens of a small Scymnus in all its stages which were inclosed.* The first brood of Iceryas in warm and exposed places at Sydney had by this time become nearly grown, some of them beginning to exude cottony matter, while others in more secluded spots were quite small. The isolated acacia tree, so full of Icerya in September, had become entirely clear, nothing but a few old and torn egg-masses being visible. With this I finished collecting the parasites and enemies of Icerya in Australia, as from letters received from Mr. Crawford, at Adelaide, dated January 11 and 12, there was little hope of obtaining sufficient material at that place for another consignment, nor would it have paid to search for *Monophlœbus* in the ground, as at the time they could not be found in large numbers in the woods. Moreover, many of their parasites had already left, while the Icerya still known to me at Melbourne and Sydney were not sufficient to make a good shipment.

A letter received at this time from you in which you directed me to visit New Zealand and study Icerya there until the arrival of the next steamer for San Francisco, in case the exposition commission would pay expenses, was shown to Hon. Frank McCoppin, who at once consented to my proposed trip. I therefore left Sydney on the steamer of January 23 with some hope of clearing up the mysterious disappearance of Icerya in New Zealand. Arrived at Auckland on the 28th, the Scales with parasites and Lady-birds were repacked from tin into wooden boxes, and were found in excellent condition. Everything within the tin boxes had the appearance of being placed there only a few hours previous. There was no indication of any mold. Some fresh Iceryas found in a private garden at Auckland, on *Acacia decurrens*, were inclosed as food for the Lady-bird larvæ. These latter Scales were in a small colony all close together on a few small branches, and numbered about eight hundred specimens. No insects preying upon them were found. At the United States consulate a letter was found awaiting me from Mr. R. Allan Wight, dated October 10, 1888, in which the writer mentioned various localities infested with Icerya, wishing me to visit Hawke's Bay, at Napier, where the Scales were still numerous, although fast disappearing, and where a good field for observation would be open. I therefore left Auckland on January 30, overland, the New Zealand Government, through our consul, having furnished me with a free pass for four months. On this trip not many observations could be made.

The Cabbage Aphis was found in large numbers all over the northern island of New Zealand as well as in Australia. A Coccinellid was found subsequently at Napier feeding upon this Aphis in large numbers. It is described by Mr. W. Colenso as *C. nova-zealandica* (Fig. 12). About fifty specimens of these were collected and placed in empty pill-boxes. Of these twenty-one were still living on my arrival at Alameda, where they were liberated. A second species was found feeding upon the Aphis in

* Specimens of this insect were also sent to Dr. Sharp, and determined as belonging to a new species of a new genus.

small numbers; this is *C. tasmanii* (Fig. 13). The Cabbage Plutella (*Plutella cruciferarum* Zell.) was here as well as all over Australia, observed to be very abundant. Mr. French, of Melbourne, had a specimen on exhibition with the name of "*Plusia crucifera*" as injurious to cabbage. The small Tineid, so destructive to potatoes in California, and no doubt already distributed over the most of the Western States, has been known in New Zealand for years, and it is doing the same mischief all over Australia, where it originated. In conversation with a merchant from Denver, Colo., recently, he said that a year ago he received three carloads of California potatoes, infested with these worms to such a degree that they could not be sold. I also met here, wherever apples are grown, with what is probably *Mytilaspis pomorum* Bouché, the species previously referred to as such.

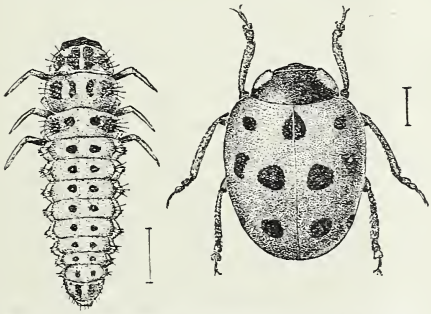


FIG. 12.—*Coccinella nova-zealandica*, larva and adult—enlarged (original).

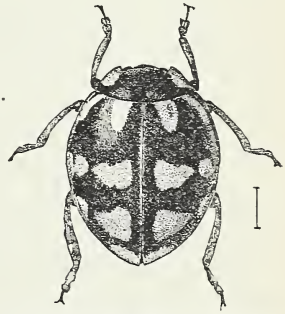


FIG. 13.—*Coccinella tasmanii*, adult—enlarged (original).

Mr. A. Hamilton, curator of the museum at Napier, who had been informed by Mr. Wight of my intended trip, awaited me and at once showed me a number of infested Acacia trees. Icerya was here still in countless numbers. Before breakfast the next morning this gentleman showed me one of the Australian Lady-birds,* saying that he found it among Icerya. On investigation they were found in large numbers in every place visited at Napier and several miles out in the country. I left Napier for Wellington on the 11th to visit Mr. Maskell. This gentleman had never had the opportunity of studying the enemies of Icerya, as the scales are not found anywhere within 80 miles of Wellington. It had been the firm belief of some persons in New Zealand that certain Ichneumonids were the destroyers of the Scales. I saw dozens of several species of these upon one orange tree infested with Icerya near Napier, not injuring them in any way, but devouring the sweet exudation from them. Larger numbers of flies were present than Ichneumonidæ, and even Crambidæ were engaged in the same performance, yet these received no share in the compliments. Mr. Maskell had received from the Cape of Good Hope about two hundred specimens of several species of Coccinellids, which, as the sender informed him,

* *Vedalia cardinalis* Muls.

were all preying upon Icerya. They were sent to Nelson and placed under tent with the Scales. A few days later, however, the wind took away the tent and nothing more has been seen since of the Coccinellids. Several species of these beetles which Mr. Maskell kindly presented me with were left with you at Washington. Amongst them I could not find the *Rodolia iceryæ*, Janson (Fig. 14), which is destroying the Scales at the Cape and, with the possible exception of one species, I do not think they will feed upon Icerya.

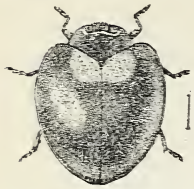


Fig. 14.—*Rodolia iceryæ*—enlarged (after Riley).

My time was too short to visit Nelson, and Mr. Maskell kindly promised to secure for me a box full of scales from that district, so as to enable me to find out whether some parasites or enemies existed there. This box was sent to me on board the steamer at Auckland and, on opening the same, several flies were found that had issued en route. Only one of them was in perfect condition; all the others were crippled. They had crawled in among the paper used in making up the parcel. No other specimens were bred and no holes were observed in the scales, so the only possibility remains in the larva of this fly being predaceous upon the eggs of Icerya. Apart from these flies no other insects were observed from the Nelson Scales. On my return to Napier I got at once to work gathering the Coccinellids in all stages. They were in such numbers that I found it not very difficult to collect here about six thousand specimens during the three days (February 14 to 16). As many as eight eggs of the Lady-bird were observed on the upper side of the female Icerya just beginning to exude cottony matter. Opposite to this on the small branch of Acacia, five young larvæ of the Lady-bird were feeding on the under side of a half-grown scale; in one instance even nine Coccinellid larvæ were found attached to a small Icerya. The mature beetles were not numerous, but every branch full of scales had a greater or less number of eggs and larvæ. The eggs are chiefly deposited among the vigorous half-grown scales. Here the largest number of the eggs and young larvæ were found. They are generally single, thrust in between the scales and fastened onto the branch, on the scale itself, and often on the under side of the scale, as the mother Lady-bird will sometimes raise the Icerya with her hind legs and thrust the egg under it. At times two or more are found together, always lying flat and in irregular position. Aside from this valuable Coccinellid, a small Scymnus was observed here feeding upon the scales, but in small numbers only. This was named for me later by Captain Broun, as *Scymnus fagus* (Fig. 15).

Fig. 15.—*Scymnus fagus*—enlarged (original).

I left Napier with my valuable lot of Lady-birds on the 17th. They

were placed in the ice-house on the steamer, and as soon as Auckland was reached I went to the freezing-house and there my Coccinellids were placed in a cool room with a temperature of 38° Fah. Having been informed that Iceryas had been very numerous almost a year ago at a gentleman's place near Lake Togabuna, several miles out of Auckland, a trip was made as soon as my Lady-birds were safe, for I was very anxious to get at the fact as to what had destroyed the Scales around Auckland, and if it were not the same insect found at Napier. I was shown a couple of Acacia trees, one of which had been destroyed by the Scales, and a second, still living, which had many Iceryas upon it. All the Scales on this small tree were examined, and, with the exception of a small Coleopterous larva within one of the egg-masses, no enemies could be observed. Both these trees were growing among old pine trees and were much shaded by them, in fact so much so that no sun-loving insect like the Lady-bird would venture into them. Close by about a dozen orange trees were growing in an open field, and on my inquiring if no Scales were upon these trees, the gentleman remarked that only about nine months since they were full of them, but that all had disappeared. These I wanted to see, and on the first tree reached, while yet at some distance, I could see, exposed to the sun on the upper side of a leaf, a black glistening spot, which was the insect looked for, the Australian Lady-bird. On this tree more Coccinellids than Iceryas were found. The Lady-birds, if not at rest on top of a leaf in the hot sun, were busily running or flying about. This is an interesting fact. All the orange trees in the open field were completely cleaned of the thousands of Scales by the Coccinellids, while closely adjoining, among the dark and shady pines (*Pinus insignis* Douglas), a large Acacia tree (*Acacia decurrens*) was destroyed by the Scales, even the adjoining branches of the pine trees being dead, and, as stated by the proprietor, from the effects of Icerya.

As yet the scales have not been observed to my knowledge on pine trees in California, yet Mr. Maskell also told me of having seen pine trees loaded with them. I observed here also an *Aspidiotus* very injurious to apple trees. The following day the place visited on my first arrival in Auckland was examined again, but only a few large females could be found. The young were just hatching, and many eggs were still present. Mr. Cheeseman had been informed by Mr. Purchas and others that Icerya existed abundantly in the woods at the English church cemetery (Paeroa), infesting *Sophora tetraptera*. He kindly accompanied me to the place, and before long pointed out the tree, which is closely related to the Acacias. We soon succeeded in finding the scales in large numbers on a few of the trees, when a careful investigation was made and a few specimens of the small *Scymnus fagus* were found. A small hemipterous insect was present among the egg-masses in all stages, the young being found within them, and two species of small spiders had built their houses among the egg-masses

also. From the many remains of the young Iceryas it was evident that they fed also on these. The Australian Coccinellid had not yet discovered this colony of scales, yet it must have existed here in numbers for at least four years. Only a few scattered specimens were found on other shrubs, but they had spread to the Mangrove bushes growing close by in large numbers. On this plant they thrive remarkably well.

Captain Broun, at Drury, the authority on New Zealand Coleoptera, was visited and asked in regard to the Australian Lady-bird. He did not know the insect, nor had he ever met with it, but he had the small *Scymnus fagus*, which seems to be more widely spread and lives upon various Scales; neither had he met with the common *C. nova-zealandica* which I found at Napier. During a ramble in the woods with the captain I found a large Coccinellid in all stages feeding upon *Ctenochiton viridis* Maskell infesting *Coprosma lucida*. This Coccinellid was identified by him as *Leis antipodum* Mulsant (Fig. 16). Upon the same tree was also found in abundance a second and smaller Scale of the same genus; this is *C. perforatus*. The captain kindly promised to send me a number of living specimens of the Coccinellid, and he kept his promise, though, unfortunately, the insect had become so rare that with assistance he was able to find only six specimens. These came in an ice-chamber well packed in a large box, but only one of them was living on arrival here.

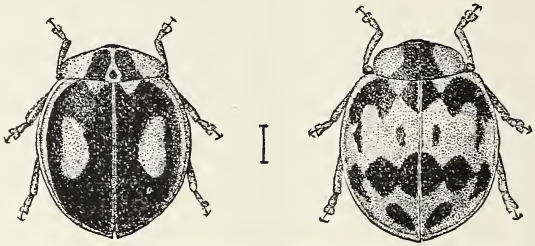


FIG. 16.—*Leis antipodum*, two varieties—enlarged (original.)

On February 25 the steamer was ready to sail. Having made arrangements with the butcher on board the previous day as to the most convenient time of receiving my insects into the ice-house, they were transferred from the freezing-house on board the steamer, which did not take more than ten minutes, and the insects were not disturbed in their dormant stage during the time. Every day on the voyage I received the answer from the butcher, to my inquiries about the parcel, "Your bugs are all right." On March 10, after leaving Honolulu, one of the boxes with the Lady-bird larvæ was examined and found in excellent condition; no dead larvæ could be found among them, and this was twenty-four days after the first were collected. On Saturday evening, March 16, we arrived at San Francisco, too late to have the insects forwarded, and I could not send them off before Monday evening, March 18. They were probably received and opened by Mr. Coquillett two days later. This would make thirty-four days that they were in-

closed, and yet they arrived in excellent condition, better than any previously received. Having been on ice for twenty-nine days, no doubt many of the eggs arrived here before hatching, and the larvæ under such conditions would make little progress in their growth.

As will be seen from these notes (and such is my firm belief), Icerya is indigenous to Australia, having spread from that country to the Cape of Good Hope, New Zealand, and our continent, and no doubt with some plants brought here. The pursers on steamers running between San Francisco and Sydney informed me that with every trip a greater or less number of plants are brought over. On these no one would notice Icerya; even an expert would overlook a few of the tiny young scales if not especially searching for them. At the time Icerya was first observed here many oranges were brought over. Mr. Sutton, of the Alameda, informed me that in 1873 the entire market in San Francisco was supplied with Australian oranges. All this matters little. We have the pest, and now the most effective enemies of it. Before long the work of the latter will be appreciated all over the State. At this date small colonies of the Lady-birds have been established in almost every district infested with Icerya, and at Los Angeles they must be present already by the thousands.

It was difficult in Australia to ascertain which was the most effective enemy of Icerya, on account of the scarcity of the latter insect during the unusually dry season of my visit. It is safe to say, however, that the Lestophonids are always and at any time ready for any Icerya, since they breed upon so many and varied Scales infesting the Eucalypti and Acacias, of which the Australian woods chiefly consist. Often Icerya will appear in large numbers in some private garden in a city, and yet, as I have been informed, they will be out of sight in a short time again. This entire clearing up is the work of the Lady-birds, for in most cases the infested scales will produce eggs, and the flies are never able to entirely clear a tree of them, in which case the Lady-bird steps in and devours Scales, flies, and all. It is only in such protected places that the scales sometimes become numerous, as it takes time for their enemies to establish themselves. The Lestophonus no doubt would in time increase here so as to keep the Icerya in check, but this would be years, for only two broods of it were observed in Australia, as many as that of its host, the Icerya, the parasite appearing about the same time as the young of the latter. I have seen about eight species of Monophlœbidæ upon which Lestophonus will undoubtedly breed.

Dr. Diez, of the Adelaide Museum, has shown me several specimens of a species of these scales, which he assures me were fully 2 inches in length when received alive from the interior of South Australia. He had written to the party who sent them for information regarding the monstrous scale-bug, yet the only light he received upon the subject was that the discoverer of the Scale was found dead in the bush near

Baroota, and he assumes that they came from that district. Such a large Coccid would be able to support several hundred of the Lestophonus. I have also bred this fly from a species of *Cœlostoma* found on a shrub at Mount Lofty, South Australia, where two specimens of Icerya were found, both invested by *Lestophonus* on a species of Acacia. In California we have to my knowledge no Scales upon which this fly would breed, with the exception of *Pulvinaria* and *Dactylopius*. Of the latter there are many species found almost everywhere; a large species almost equal in size to Icerya exists upon our Redwood trees (*Sequoia*). This no doubt will in time be attacked by the flies. I have not the least doubt that in time this *Lestophonus* will do effective work upon Icerya even if slow (too slow for the Americans, as Mr. Wolfskill remarked). So far I have seen little progress of it. On my visit to Los Angeles (April 12), it seemed that very few remained of the vast number of flies received here in good condition. All had been placed under one tent, erected over a tree for the purpose of propagating, instead of forming a new colony with every consignment received; yet it is to be hoped that very many of the flies have escaped from the tent.

As far as the Lady-bird is concerned it will show itself, or rather has done so already. They never were found by the writer except feeding upon Icerya, and yet there must surely exist in Australia some other scales upon which they feed. The work this little insect is able to accomplish is shown by the fact that by chance it went over to Auckland, New Zealand, where the Icerya was in a flourishing state, having destroyed nearly everything about five years or so since, and there cleared nearly the whole district around Auckland within about two years. From here it has spread south as far as Hawk's Bay without any artificial help, everywhere increasing in numbers as long as the food would last. I shall be greatly mistaken if this one insect alone is not master of the situation within two years' time, although we have comparatively few to battle with. It will need thousands everywhere to clean up the millions of scales. I has no time while in the field to study much of the life-history of this valuable insect. My first motto was always "get as many as possible." If once established here, the life history may be studied at leisure.

I will, however, relate part of the doings of one pair of these insects. On February 9 a few beetles and pupæ were collected in a glass jar. Two male Lady-birds were noticed running and pushing around one of the pupæ in which one of the female Lady-birds had just issued and was within the case with soft and tender wings and about helpless. Soon the male succeeded in pushing her out, and immediately after this had been accomplished, one of them united with her at about 3 p. m. This pair were placed in a small wooden box and they remained in copula until the following morning at 7. They were left in this box until February 17, when they were placed in a large jar with twigs of Acacia full of Iceryas. No eggs were observed in the box, which was completely

clean, with the exception of the numerous red spots produced by the Lady-bird, for they had subsisted on their own eggs during their confinement. As soon as the female Lady-bird was among the scales she became quiet, stopped, and deposited an egg upon the twig. As soon as this was done she turned around and devoured the same, which took her about a half a minute. A few moments were spent in cleaning herself and then another egg was brought forth and eaten. After this and another wash she attacked and devoured a half-grown scale. This was eaten into from the back, very quietly at first, yet in a little time she became lively, almost furious, tearing the scale off from its hold by the beak and turning it up and down in the air with the mouth-parts, assisting in this with the anterior legs. In about one minute this was devoured and nothing but the empty skin left, after which she went to work, business-like, and deposited eggs quietly, sitting at rest upon the scales, and every few minutes thrusting an egg in between or generally under them. A very large scale was lifted with the posterior legs and the egg thrust beneath. All the strong attempts at love affairs by the lively and not hungry male were resisted. I was careful to see that twigs with nothing but Icerya on them were selected for food; at least no young larvæ could be observed on them; yet the second day after the Coccinellids were placed in with them, young larvæ were seen, and they came out so fast that within a few days my jar was a living mass of them.

On February 22 a few of the larvæ were full grown and settled down in a quiet place, fastening the ends of their bodies down with a thick and sticky substance and remaining in this way, becoming shorter and stouter, for four days. On the 25th the first pupa was observed; from this the mature beetle hatched in the evening of the 28th. Another appeared the following day. Again, on March 3, a pair of the bred Lady-birds were placed together, with clean food, and the next day, March 4, eggs were observed which hatched on the 8th. This I could not carry through, as the food began to dry up; in fact, on March 18, many grown and hungry larvæ were devouring each other in this jar, and even the mother of them, which was still living, was noticed devouring one of her young, a larva. Three times, at intervals, this pair were observed in copulation. Eleven beetles of this last brood reached maturity, having had nothing to feed upon but one supply of scales that had already been boxed up for eight days, the beetles having been born and forced to live upon one another. Taking four days for the eggs to hatch, about eight days for the larvæ to grow, three days until pupating, and four days more for the pupa to emerge, this would only make nineteen days from the egg to the mature insect, providing the weather is warm. No doubt we will see cases where, in less time than this, all the stages are gone through at Los Angeles in hot weather, and we may expect at least fifteen broods annually of this insect to two of Icerya.

Another most important insect is the moth *Thalpochares cocciphaga* Meyrick. It is greatly to be hoped that this insect will be introduced here. I have been able to get about a hundred larvæ here in good condition, yet what became of them I am not able to state as yet. The insect is apparently easy to breed. Five of the larvæ were placed in a pill-box in the field during January and overlooked. During April, on opening the box at Alameda, I found that four of the moths had issued, copulated, and deposited many eggs. The young larvæ, however, had already left the box and no trace of them could be found. It would have been easy with the number received here, had a little care been bestowed upon them, to breed and introduce them upon most any of our larger Scales.

The *Chrysopa*, of which eggs and larvæ were sent over with every shipment, excepting the last, have been successfully introduced. In April, while in Los Angeles, several of the insects were noticed upon orange trees in Mr. Wolfskill's orchard.

Several species of *Scymnus*, about six in number, that were sent, all live upon *Coccidæ*. The largest of them was abundant in Brisbane upon various soft scales, and was also found at this place upon Icerya.

Mr. Webster brought to me from Tasmania a box full of Eucalyptus twigs with *Eriococcus eucalypti*, the *Scymnus* so numerous at Melbourne, and sent here in numbers, together with two small moths, a Pyralid and a Tineid, which were feeding upon the *Eriococcus*.* These, as all other insects, were turned over to Mr. Coquillett. Various other beneficial insects were observed during my four months' work in Australia, all of which if introduced here would be of great value. One of these deserves to be mentioned. It is one of the largest Lady-birds, and had cleaned whole apple orchards of the Woolly Aphis in South Australia and Victoria. They were also observed to feed upon Lecanium.

All material collected and studied in Australia relating to this subject and otherwise of importance will be mounted and sent to you with the notes thereon.

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* These moths we have no means of now determining, even if described. The Tineid much resembles *Euclemensia bassettella* of this country, and the other is a Phycid near *Dakruma*.